

# RESEARCH, DEVELOPMENT & TECHNOLOGY TRANSFER QUARTERLY PROGRESS REPORT

Wisconsin Department of Transportation  
DT1241 02/2011

## INSTRUCTIONS:

Research project investigators and/or project managers should complete a quarterly progress report (QPR) for each calendar quarter during which the projects are active.

<b>WisDOT research program category:</b> <input type="checkbox"/> Policy research <input type="checkbox"/> Other <input checked="" type="checkbox"/> Wisconsin Highway Research Program <input type="checkbox"/> Pooled fund TPF#		Report period year: <b>2013</b> <input type="checkbox"/> Quarter 1 (Jan 1 – Mar 31) <input type="checkbox"/> Quarter 2 (Apr 1 – Jun 30) <input type="checkbox"/> Quarter 3 (Jul 1 – Sep 30) <input checked="" type="checkbox"/> Quarter 4 (Oct 1 – Dec 31)
Project title: <b>Permeability Performance and Lateral Load for Granular Backfill behind Abutments</b>		
Project investigator: <b>Pavana Vennapusa and Brent Phares</b>		Phone: <b>515-294-2395</b> E-mail: <b>pavanv@iastate.edu bphares@iastate.edu</b>
Administrative contact: <b>Angela Pakes</b>		Phone: <b>(608) 890-4966</b> E-mail: <b>apakes@Sustainability.wisc.edu</b>
WisDOT contact: <b>Kimberley Dinkins</b>		Phone: <b>(608) 267-2828</b> E-mail: <b>KimberleyR.Dinkins@dot.wi.gov</b>
WisDOT project ID: <b>0092-14-03</b>	Other project ID:	Project start date: <b>8/13/2013</b>
Original end date: <b>2/12/2015</b>	Current end date: <b>2/12/2015</b>	Number of extensions: <b>0</b>

## Project schedule status:

☒ On schedule ☐ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

## Project budget status:

Total Project Budget	Expenditures Current Quarter	Total Expenditures	% Funds Expended	% Work Completed
\$150,000.00	\$16,542.71	\$32,938.51	21%	15%

## Project description:

The current WisDOT Bridge Manual recommends using “pervious” granular backfill behind bridge abutments to prevent lateral water pressures on the abutment walls. The granular backfill material is considered “pervious” or “free-draining” based on its grain-size distribution properties. However, the “free-draining” assumption of granular backfill does not properly consider:

- granular backfill material properties in terms of its water infiltration capacity, permeability, and water retention characteristics,
- effect of undrained water on the lateral earth pressures exerted on the abutment walls, and
- short- and long-term effectiveness of the pipe underdrain.

The specific research objectives of this work are to:

- Identify the current state of the practice of other state DOTs and scholarly articles addressing the influence of granular backfill permeability and water retention characteristics on the lateral earth pressure distribution and short- and long-term effectiveness of the pipe underdrain system, and collect relevant data for use in this research project.
- Conduct a thorough field investigation at 4 sites with structural backfill and granular grade 1 materials as selected by the project Technical Oversight Committee (TOC) to: (a) measure in situ permeability and water retention characteristics of the backfill materials, (b) measure in situ shear strength characteristics of the backfill materials, (c) monitor lateral earth pressures and pore pressures behind abutment walls, and (d) evaluate the performance of the pipe underdrain systems both in short- and long-term.

- Conduct a thorough laboratory investigation of the materials collected from the field sites and the alternative materials including recycled asphalt pavement (RAP) and foundry sand, to determine their shear strength, water retention, and permeability characteristics.
- Develop a practical quantitative approach to analyze lateral earth pressures on abutment walls accounting for water infiltration rate, pore pressure distribution due to infiltrated water flow, performance of pipe under drain, total unit weight, and shear strength characteristics of the backfill material.
- Develop recommendations specific to the current state of the practice of WisDOT's abutment granular backfill design and construction practices, and the impact of using alternative materials (RAP and foundry sand).

The project has been divided into the following five phases: (I) Literature Review, (II) Field and Laboratory Investigations, (III) Analysis and Evaluation of Field and Laboratory Testing, (IV) Evaluation of Alternative Materials, and (V) Final Report.

**Progress this quarter** (includes meetings, work plan status, contract status, significant progress, etc.):

Progress has been made this quarter on Phases I and II.

Phase I – Literature Review: An organized effort was made to collect references related to the following topics, as indicated in the project proposal: (a) abutment granular backfill drainage design and construction procedures, (b) permeability of granular backfill materials, (c) effects of water retention (pore pressures) in backfills on lateral earth pressures, and (d) alternative materials and procedures to improve drainage and reduce lateral earth pressures.

The effort involved searching on-line sources including: (a) Google, (b) Engineering Village, (c) Web of Knowledge, (d) Swedish Geotechnical Institute, (e) American Society of Civil Engineers (ASCE) library, (f) Transportation Research Information Services Database (TRID), (g) WorldCat, and (i) several state DOT search engines. Currently, the literature is being organized and will be continued in the next quarter. A preliminary summary of literature review findings will be provided in the next quarterly report.

Phase II – Field and Laboratory Testing: A bridge abutment backfill project on SH70 near Boyceville, WI (Figure 1) was identified by Wisconsin DOT for field testing and instrumentation. The ISU research team worked with Mr. Keopp and an onsite representative from Stevens Engineers to conduct field testing and instrumentation. Field testing and instrumentation was performed on October 31 to November 1, 2013. The project involved removing existing box culvert and replacing with a single span integrated concrete bridge with concrete abutments supported on cast-in-place piles. The height of abutment backfill was about 6 ft. A drain tile was located in the backfill at about 5 ft depth from the top of the abutment. The structural backfill material used on the bridge was poorly graded sand (classified as SP) with about 2% fines passing the # 200 sieve. The abutment backfill was topped with aggregate subbase and asphalt pavement.

The ISU research team conducted field testing and instrumentation on one of the bridge abutments (west abutment). Earth pressure cell (EPC) and pore pressure (PP) transducers were installed in the bridge backfill material to measure lateral stresses and pore pressures at several depths (Figure 2). Backfill material was placed and compacted to about 2 in. below its final grade, prior to our arrival. The backfill material was carefully excavated down to desired depths and compacted in thin layers (1 to 2 inches) using a hand compaction device after installing the sensors (Figure 3). Sensors were installed at four locations vertically from the top of the abutment to about 5 ft below the top of the abutment. The bottom sensors were located just above the drain tile, to capture the highest possible pore pressures due to the infiltrated water. The transducers were connected to an on-site Campbell Scientific datalogger system, which has been continuously logging data every 1 min. A field visit is planned early next quarter to download the instrumentation data.

Dynamic cone penetrometer (DCP) tests were conducted in the backfill material (Figure 4), down to about 9 ft below the top of abutment, to measure in situ shear strength properties and assess compaction conditions of the backfill material. DCP tests were conducted at 1 ft, 2 ft, 3.5 ft, and 5 ft away from the abutment (along the centerline) and about 10 ft away from the abutment in the existing subgrade. Field observations and test results indicated layers of loose backfill material. Air permeability testing (APT) and core hole permeability (CHP) testing was performed in the backfill material to measure the permeability characteristics of the backfill material (Figure 5).

Laboratory classification and grain-size analysis tests are completed on the backfill material. A laboratory testing matrix was developed to measure shear strength properties, laboratory permeability characteristics, and infiltration characteristics (using bridge abutment scale model developed at ISU) of the backfill material.

**Anticipated work next quarter:**

The following activities are anticipated during the next quarter:

1. Continue literature review process.
2. Contact Wisconsin DOT for potential projects for instrumentation and order required instrumentation.
3. Continue laboratory testing and analyze field testing results from the first project.
4. Download field instrumentation data from the first project and analyze the results.

**Circumstances affecting project or budget:**

None.

**Attach / insert Gantt chart and other project documentation**

	MONTH																	
	Aug-13	Sep-13	Oct-13	Nov-13	Dec-13	Jan-14	Feb-14	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15
Phase I																		
Phase II																		
Phase III																		
Phase IV																		
Phase V																		
TOC Review, Revision, and Final Submission																		

FOR WISDOT USE ONLY

Staff receiving QPR: K. Dinkins	Date received: 1/8/14
Staff approving QPR:	Date approved:



**Figure 1. West abutment on SH70 near Boyceville, WI**



**Figure 2. PP and EPC transducers installed along the face of the west abutment wall in the backfill material**





**Figure 3. Compaction of backfill material in thin layers after installing PP and EPC sensors at multiple depths**



**Figure 4. DCP testing on backfill material**





**Figure 5. Air permeability testing (top) and core hole permeability testing (bottom) on bridge abutment backfill**